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HUMAN SOUND LOCALISATION WITH ARTIFICIAL HEAD RECORDINGS

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Abstract

For the implementation of binaural technology it is useful to have a well-defined artificial head. Localisation performance of a group of listeners is compared for binaural recordings made with several different artificial and real heads. Earlier results show that artificial heads may be improved to match the performance obtained when using a human for binaural recording. The performances of newly developed artificial heads are compared to that of human heads. Results from the binaural systems and real life listening are presented.

1. Introduction

The described listening experiment follows logically from a series of investigations using an experimental set-up of 19 loudspeakers in a standard listening room. A signal is sent to one of the loudspeakers which a listener should identify. This is done in a normal (real life) listening situation as well as for binaural recordings of the same events played back through headphones. It was seen in [1] that when compared to real life, localisation performance was preserved with individual recordings, i.e. recordings made in the listeners own ears. Non-individual recordings (made in another person's ears) resulted in an increased number of errors for sound sources in the median plane. In [2] 30 human recording heads were ranked according to the localisation performance of 20 listeners. This indicated that if non-individual recordings originate from a carefully selected human head, it is possible to reduce the number of errors substantially as compared to non-individual recordings from a randomly selected human head.

Artificial recording heads are designed to approximate human heads acoustically. In [3] the localisation performance with artificial heads resulted in an increased number of errors independent of the recording technique, when compared to real life. Yet recordings made with a carefully selected human head (from [2]) resulted in a better localisation performance than that obtained with the then available artificial heads. This encouraged the design and production of a new artificial head named Valdemar. The artificial head was designed to give head related transfer functions (HRTFs) that fulfil criteria based on measurements made on a group of people. Localisation test results with this artificial head and three other artificial heads were reported in [4]. In the current experiment new recordings were made with artificial heads and human heads.

2. Experimental set-up

The loudspeaker set-up, where 19 loudspeakers were placed in a standard listening room, was the same as for the experiments described in [1], [2] and [3]. For a complete description of and motivation for the set-up see [1]. The responses of all the loudspeakers were measured in an anechoic chamber. An inverse filter was designed from the measurements for the equalisation of the loudspeakers. This was implemented by off-line processing of the signals fed to the loudspeakers. As stimulus material female speech was recorded in an anechoic chamber. The gain through the complete recording and playback system was made unity. This ensured that the natural speech level was maintained. White noise and pink noise signals were created to have the same overall RMS value as the speech.

3. Recording with heads

Digital recordings of the signals presented to the loudspeakers were made with 5 artificial and 2 real heads. They were Knowles Electronics KEMAR, Neumann KU 100, Aachen University - Institute of Technical Acoustics (ITA), Brüel & Kjær 4100, Valdemar, AVH (human) and DOL (human). The two human heads were those that gave the best localisation performance of the 30 heads in [2]. Valdemar was equipped with copies of the pinnae of DOL. The first four heads have build-in microphones and for the last three blocked ear canal microphones were used. Particular attention was given to the placement of the heads in the loudspeaker set-up.

4. Reproduction of binaural recordings

The binaural recordings were reproduced by means of a Sennheiser electrostatic headphone (HE 60) and amplifier (HEV 70). The headphone transfer function (PTF) was measured 5 times on both channels of the recording heads. From the measurements an equalisation filter was designed so as to obtain a unity gain through the system after filtering. Where blocked ear canal microphones were used inverse filters were designed from measurements made with the headphone on 20 people's ears. The microphones were placed at the entrance to the blocked ear canals of the people, as was the case for the recording heads. Inverse filtering was implemented by off-line processing of the digital recordings. This allowed for the sound pressure level in the ears to be the same when listening to the processed binaural recordings and in the original sound field.

5. Subjective experiment

As for the preceding studies localisation responses were collected from listeners through an identification experiment. Directly after playback of a stimulus through a loudspeaker or a binaural reproduction of the event a listener chose one of the 19 loudspeaker locations he/she believed the sound originated from. A small 'digitiser' placed on the listener's lap was employed to collect answers. It used a sketch of the loudspeaker lay-out which is shown in Figure 1 below.

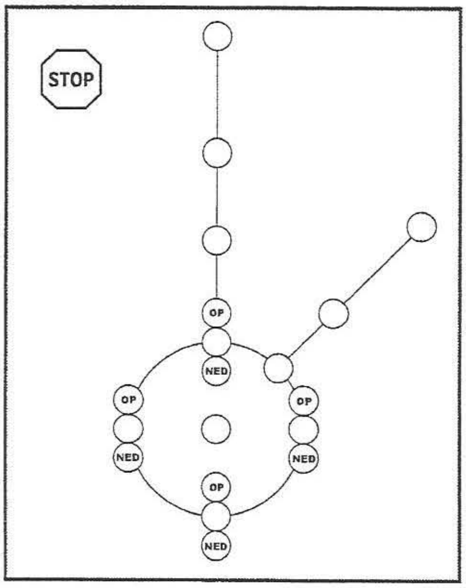

Figure 1 The listener had a small tablet (digitiser) on his/her lap showing this sketch. When the 'traffic light' prompted the listener to answer he/she selected one of the defined positions with a pen.

To aid the listener during the subjective testing his/her actions were prompted by a 'traffic light'. A red light indicated to the listener to look straight ahead and keep the head still during a sound presentation. A green light indicated that the listener was free to answer after which a yellow light would alert the listener that another red light was coming up. Cameras were employed to ensure that the listener kept his/her head still during stimulus. The stimulus playback and data collection were controlled by the a computer leaving the experimenter free to control for head movements.

For the binaural systems the experimental set-up was the same as for the real life experiment and during playback the loudspeakers were visible to the listener. The order of the playback through the binaural systems was randomised with the real life playback so that every listener heard the systems in a different order.

6. Results

At the time of the submission of this article results from the subjective experiment were not yet available. Once the subjective experiment is completed data analysis will be done and the results presented at the Nordic Acoustical Meeting.

7. References

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